THE EFFICIENT RECYCLING OF POLYVINYL BUTYRAL FROM LAMINATED GLASS CONSTRUCTION WASTES IN ENERGY STORAGE APPLICATIONS IN A CIRCULAR ECONOMY APPROACH

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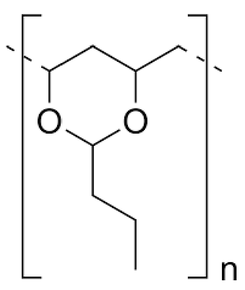
Introduction

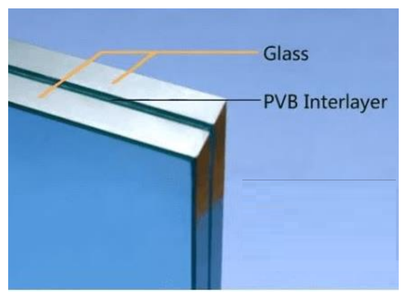


Laminated glass is a type of safety glass obtained by bonding two glass layers with a polymeric interlayer to keep glass fragments together in case of shattering.

Typically, Polyvinyl Butyral (PVB) is used as the interlayer polymer in laminated glass and its use in construction and automotive components is growing, therefore the end-of-life should be addressed.

Indeed, laminated glass wastes are currently gathered and recycled through a well-established chain, but the target of that process is to recover the glass only, while **PVB is just considered as a waste**.

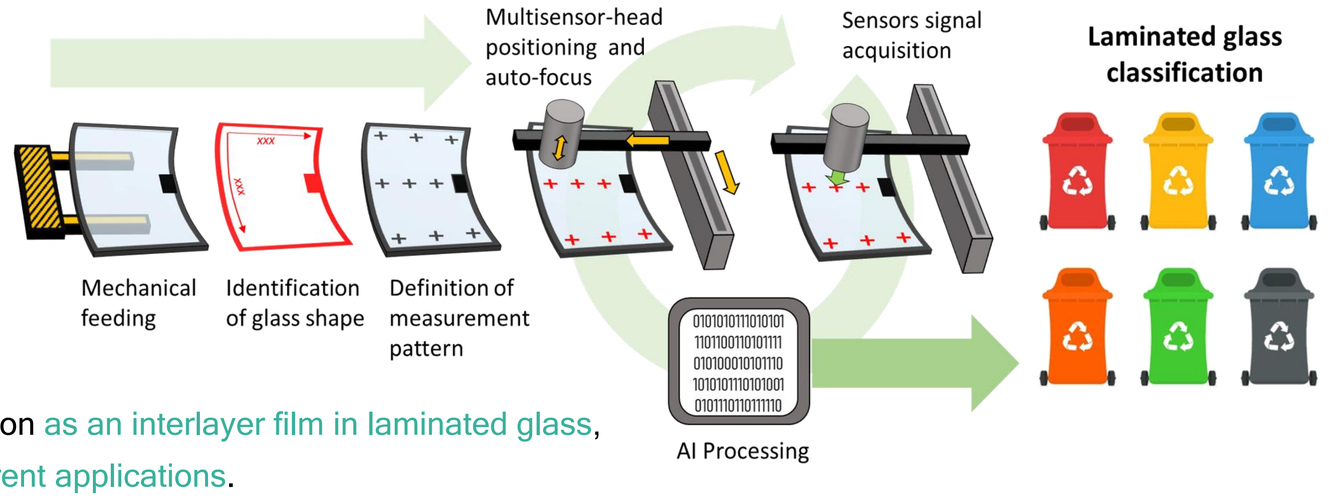
Up to now, most of the post-consume PVB is incinerated or landfilled, and only the 9% is repurposed in secondary uses.



Recycling of PVB from laminated glass

Recycling of PVB presents several difficulties related to the contents of glass, humidity, mixing of compositions, and polymer optical degradation which prevents reusing as interlayer.

SUNRISE European Project will develop an innovative optical multi-sensor sorting tool based on industrial in-line techniques (Raman, IR, Fluorescence and Optical Spectroscopy) and AI algorithms, which will allow optimal classification of laminated glass according to composition and degradation.



- the high-quality recycled PVB will be reused in its primary application as an interlayer film in laminated glass,
- the low-quality recycled PVB will be tentatively repurposed in different applications.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 958243

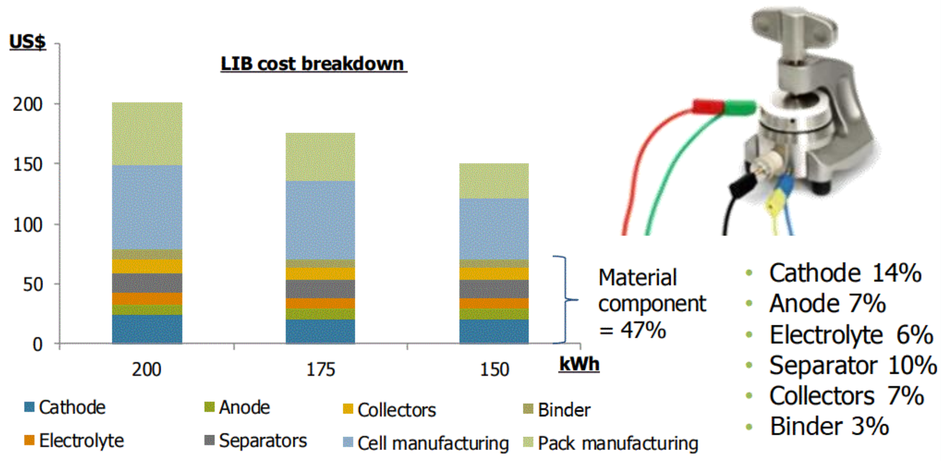
Re-use of PVB in energy-storage application

In the framework of the SUNRISE Project, the aim of our group is to exploit new strategies for the re-use of the fraction of PVB which does not fulfill the requirements for the re-integration in the original glass manufacturing process.

Particularly, the recycled PVB will be used as a binder in the electrode preparation and/or as a separator in lithium or sodium ion batteries (up to transform it into a polymeric electrolyte membrane for solid-state batteries).

The **target costs** have been projected at **< 10$/kg for the binder and <60$/kg for the separator** to be competitive with conventional binders and separators, such as CMC and PP/PE, respectively.

R. Baylis, "LIB raw material supply chain bottlenecks: looking beyond supply/demand/price", *Roskill Consulting Group Ltd.* **2017**

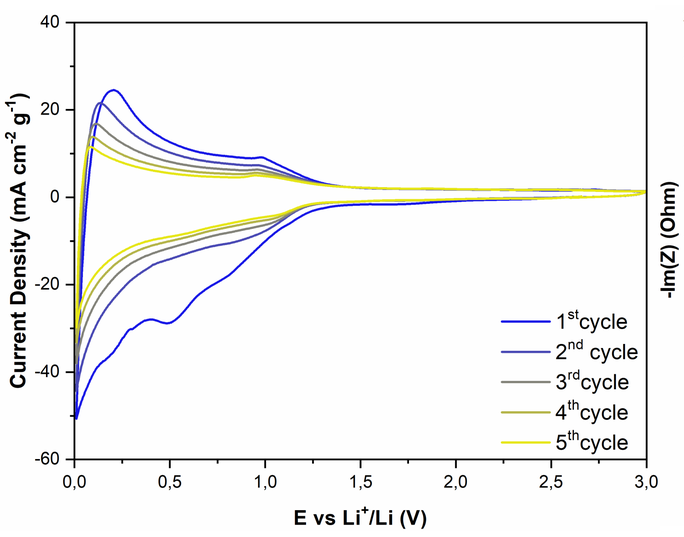


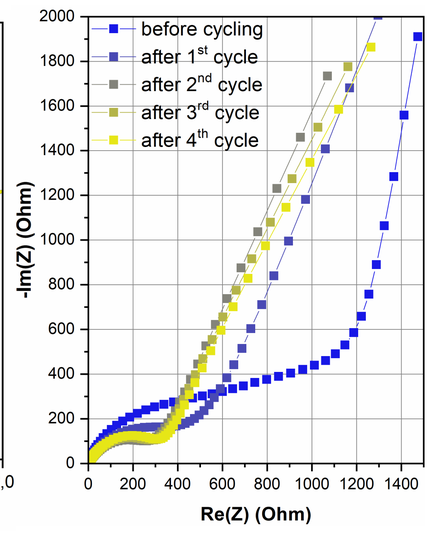
Preliminary results with commercial PVB

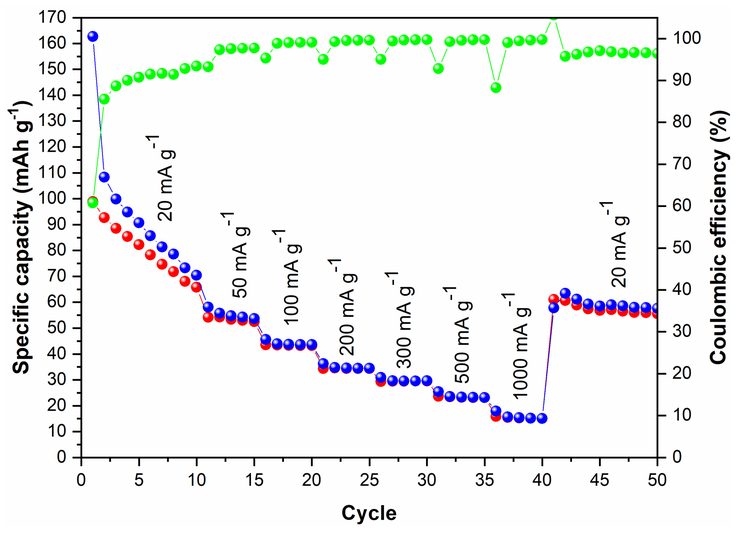
A few preliminary tests were carried out with commercial PVB (Sigma-Aldrich), in order to compare these results with those obtained by recycled PVB.

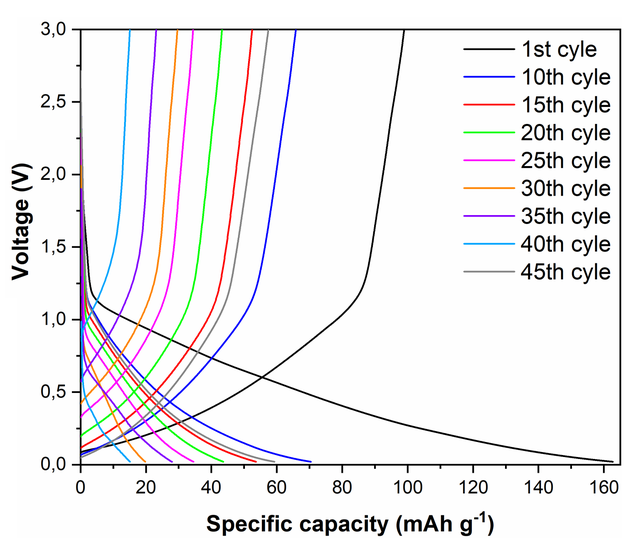
Some PVB-binded electrode films were prepared over a foil of Cu current collector, using hard carbon (HC) as anodic active material. These electrodes were compared with some standard CMC-binded electrodes prepared in the same conditions.

- A higher content of PVB than CMC was required to maintain the mechanical properties of the electrodes (10% with respect to 5%).
- The PVB-binded electrodes were stable upon cycling, no active material loss was detected because of the possible dissolution in the liquid electrolyte.
- The specific capacity of PVB-binded HC is slightly less than the CMC-binded one in the same conditions, the procedure is still to be optimized before testing recycled PVB.









Slurry was made by mixing commercial hard carbon (HC), with carbon black (CB) and PVB (HC:CB:PVB=87:3:10 by weight) in ethanol.
Electrodes were prepared by Doctor Blade casting on Cu foil.
Electrochemical tests were performed at room temperature in the configuration Li / 1.0 M $LiPF_6$ in EC-DMC / HC.

D. Bresser, D. Buchholz, A. Moretti, A. Varzi, S. Passerini, "Alternative binders for sustainable electrochemical energy storage", *Energy Environ. Sci.* **2018**, 11, 3096-3127.
A. Hajizadeh et al., "Electrophoretic deposition as a fabrication method for Li-ion battery electrodes and separators – A review", *J. Power Sources* **2022**, 535, 231448.